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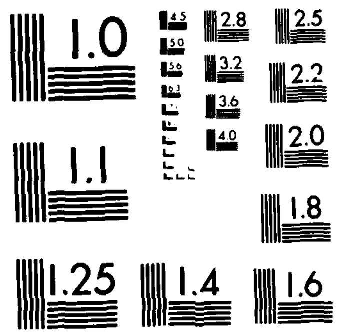

MICROCOPY RESOLUTION TEST CHART
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ELECTRIC FIELD PROCESSING SYSTEM FOR THE S3-2 SATELLITE

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AIR FORCE GEOPHYSICS LABORATORY
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Air Force Satellite S3-2 carried on board sensors to measure the intensity of electric fields encountered along its orbit through the ionosphere and magnetosphere. The data which is collected is digitized and stored on magnetic tape. Three software systems are described which access this data, together with supporting information such as satellite ephemeris, the local values of the Earth's magnetic field, and data from other on board sensors. Depending upon the particular system selected, the electric field may undergo

Block 20 (Continued)

various levels of processing. The results are presented as listings and computer plots.

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Acknowledgement

The original design and development of the software procesing systems described in this report are the work of Dr. Shu T. Lai. Many of his programs continue to be used, either intact or with minor modifications, in the current versions of these systems. Analysis procedures used in these systems were formulated as a collaborative effort by a group which included, in addition to Dr. Lai, Drs. M. Smiddy, W. J. Burke, and M. C. Kelley.

The support and guidance of Mr. Robert E. McInerney, Data Systems Section Chief, and Ms. Eunice C. Cronin, Computer Center Branch Chief, are greatly appreciated.

MEASUREMENT OF IONOSPHERIC/MAGNETOSPHERIC ELECTRIC FIELDS

1. Introduction

This report describes three software systems developed for the analysis, listing, and display of electric field data obtained by Air Force research satellite S3-2. The systems differ in the extent to which the data is analyzed.

The S3-2 satellite was launched into a polar orbit with initial apogee, perigee and inclination of 1557 km, 240km and 96.3°, respectively. Its orbital period is approximately 1 1/2 hours. S3-2 is spin stabilized such that its spin axis is nearly perpendicular to the orbital plane in a cart-wheel sense. The initial nominal spin period was 20 sec; for revolution 9000 and subsequent rev's the nominal spin period was altered to 23 2/3 sec. The spin plane of the satellite was also slighlty modified at this time. The experimental life time of the satellite extended from 9 December 1975 to 1 May 1978; data was gathered for selected intervals during this period.

The electric field experiment on S3-2 was designed to consist of three orthogonal dipoles: two in the spin plane and one along the spin axis. One of the dipoles in the spin plane failed to deploy. The dipole along the spin axis is subject to time varying contact potentials which are not readily related to ambient conditions. Telemetered to Earth, the measured data are available, in sampled form, for digital processing. The S3-2 satellite also carries other instruments on board including magnetic sensors, an energetic electron spectrometer, thermal-ion sensors, and a thermal electron sensor. Discussion of these experiments and their interrelationships with the electric field experiment may be found in Reference 1.

One of the processing systems to be discussed, the STANDARD ELECTRIC FIELD System,* makes considerable use of software described previously.[2] This system demodulates the data of the spinning dipole and empirically models charging effects to obtain average ambient electric fields in quasilocal-vertical and geomagnetic coordinates. A recent modification expands the capabilities of STANDARD ELECTRIC FIELD by computing the "goodness" of fit obtained in the demodulation; and, by utilizing the $\bar{E}\cdot\bar{B}=0$ condition (which normally prevails for all but highly disturbed ionospheric conditions), to provide estimates of the field component in the spin plane which is perpendicular to the direction of the rotating boom. Output and plot programs have been modified to display these new results.

A second system, the RAWDATA System, uses software developed at the same time as STANDARD ELECTRIC FIELD, but not described in Reference 1. This system unpacks the raw data from selected experiments and plots them in strip-chart form along with a border containing relevant ephemeris information.

The third system to be discussed, DETAILED PROCESSING, is a comprehensive system for unpacking, listing and display of the data in greater depth than afforded by the RAWDATA SYSTEM.

Recently all of these systems have been restructured into the form of CYBER Control Language (CCL) procedures with very simple input requirements. This makes these systems very easy to operate in a production mode.

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* The current operational version of this system has also been referred to as NEW E-FIELD to distinguish it from an earlier version of the system. In the context of this report, NEW E-FIELD and STANDARD ELECTRIC FIELD are intended to be synonymous.

2. RAWDATA System

This system unpacks a packed raw data tape for vehicle S3-2 and plots data from selected experiments in strip chart form along with a border containing relevant ephemeris information. The package contains the following programs:

1) DTACS - accesses and copies 3 data files from the S3-2 raw data tape
2) ORACS - accesses and copies the required B/L ephemeris for the orbit
3) BILD3 - unpacks and plots the data, using the files prepared by DTACS and ORACS.

Table 1 gives additional information for these programs. Figure 1 illustrates the flow of Operations for the RAWDATA System.

Program Deck	Form	Cataloged as PF Name
DTACS	SOURCE	ACSDTSR
ORACS	SOURCE	ACSORSR
BILD3	UPDATE	RAWDATAPL

Table 1. Programs Comprising the RAWDATA System

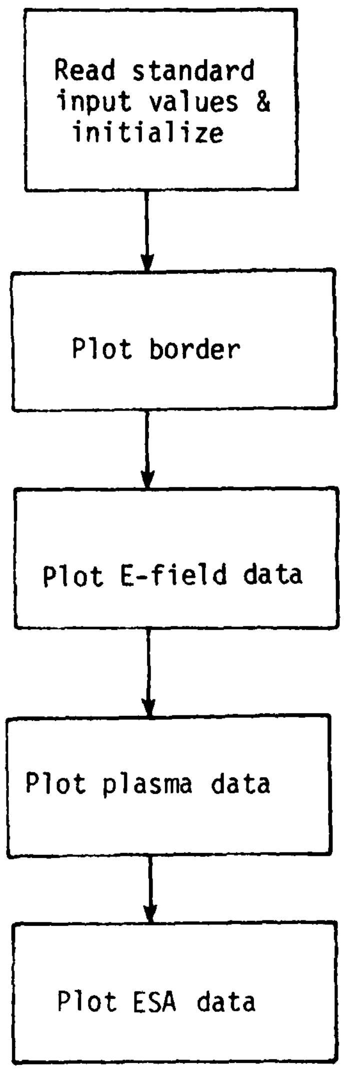


Figure 1. Sequence of Operations for RAWDATA System

2.1 CCL Procedures

Four different procedures have been constructed to link these programs. They differ in the type and quality of the plots produced. To use them it is required that program files DTACS and ORACS be cataloged on permanent files in source deck form, while BILD3 must be cataloged as an UPDATE program library (see Table 1). The four procedures are described briefly as follows:

2.1.1 Standard Form - Offline Plotter

The S3-2 data tape, the rev to be used on this tape, and the B/L ephemeris tape, are all specified by the user. The CCL procedure compiles and loads programs successively on files DTACS and ORACS, respectively, to be used to copy the required data and B/L ephemeris files to disk. The ephemeris file is also saved as a permanent file.

BILD3 is next accessed, compiled, and loaded to unpack and plot the data using the disk files created by DTACS and ORACS. The plotter instructions are written to a work tape to permit recopying or multicopying without rerunning the programs.

2.1.2 Online Plotter

The online procedure is the same as for the offline plotter, above, except that the plot is submitted to the online plotter.

2.1.3 Tektronix/Microfiche - No B/L Ephemeris

This procedure is the same as for the plotter except that update corrections to program BILD3 are incorporated for use of the microfiche plotter, and B/L ephemeris information is eliminated. This procedure is useful for quick turnaround of raw data plots when the B/L ephemeris information is not available. Detailed instructions for running this deck are included as comments in the deck itself.

2.1.4 Microfiche/Tektronix with B/L Ephemeris

This procedure is the same as that of Section 2.1.3, except that B/L ephemeris information is included.

2.2 Inputs

Punch card inputs are described in Table 2. These cards are contained in the CCL procedure and are located immediately following the "DATA, BILDBIN" card. The magnetic tape has a VSN of the form V3XXXX and contains 6 level 17 files per orbit (usually one orbit per tape). Only Files 4-6 are used . These are copied by the procedure to TAPE3, TAPE1, TAPE2 (temporary disk files), respectively, which contain data from the energetic electron spectrometer, electric field, magnetic field, thermal ion, and thermal electron experiments. Detailed descriptions of the data formats are given in References 3-7.

For standard online and offline plots a horizontal scale of 100 sec/inch pen is recommended with data sampled at 0.25 second intervals. This would produce, for a 6000 second orbit, a plot 60 inches long, plus a few inches for the plot labels.

For microfiche, a 60 sec/inch scale is recommended. Ten minutes of data are plotted per frame, requiring 10 frames for a 6000 second orbit. For Tektronix display, data should be sampled at 1 second to limit CP time. (The Tektronix generally requires significantly greater CP time than the other devices to produce a given plot).

2.3 Output

o Printed Outputs

Printed output consists of a listing of the header records for the three data files used on the S3-2 data tape.

Card No.	Variable Name	Card Col.	Format	Variable Description
1	GMTS	1	F10.5	user set start time; if zero the first time on the tape is used
1	GMTF	11	F10.5	user set finish time; if zero the last time on the tape is used
1	SPI	21	F10.5	second per inch for the time division on the horizontal border of plot
1	YB	31	F10.5	inches to the top boarder of the plot; defines the vertical scale.
1	DELT	41	F10.5	number of seconds between successive samples.

(card 1 is read in main program)

Card No.	Variable Name	Card Col.	Format	Variable Description
2,4	INDEX(I), I=1,JSET		16I5	data channels to be plotted

(cards 2 and 4 are read in main program)

Card No.	Variable Name	Card Col.	Format	Variable Description
3,5	NDTSETS	1	I5	number of data channels
3,5	NWDS	6	I5	number of 60-bit words per record
3,5,6	(IG(I,1), I=1, NDTSETS)		14I5	number of packed (12-bit) data words in each channel per record
		7 on, may be continued on additional cards as in second instance		

(cards 3, 5, and 6 are read in subroutine SELECT3; card 3 is for TAPE1 and card 5 is for TAPE2)

Table 2. Input Cards for RAWDATA System

o Magnetic Tape

A work tape is produced for use by the offline plotter. The number of this work tape is entered in the day file by the operator. The offline plotter is employed because of the appreciable duration of a typical plotting session. The work tape number is specified so the plot may be rerun without additional computer time in the event of a hardware failure in the plotter or a request for duplicate plots.

o Plots

Examples of typical offline and Tektronix/Microfiche plots are shown in Figures 2 and 3, respectively. Data is displayed from a variety of sensors. Consider Figure 2, for example. Total electric field in the translating frame of the satellite as measured using both the high and low gain amplifiers connected to the axial and rotating boom antennas is presented in traces 1,3,4 and 5 (numbered from the top). Trace 2 shows one component of the magnetic field as measured by the satellite's on board magnetometer. Trace 6 is the measurement made on the ambient electrons. S3-2 is equipped with two arrays of four passive thermal ion sensors consituting the ion drift meter experiment. Measurements obtained by one of these eight sensors are presented in traces 7 and 8. Trace 8 shows the range selected by the automatic ranging electronics in the experiment. Trace 7 shows the actual ion current. The current is modulated as the sensor on the rotating satellite faces in the ram and antiram directions; the largest modulations occur when the ambient plasma is predominately O^+. Results of the energetic electron spectrometer are shown in Trace 9.

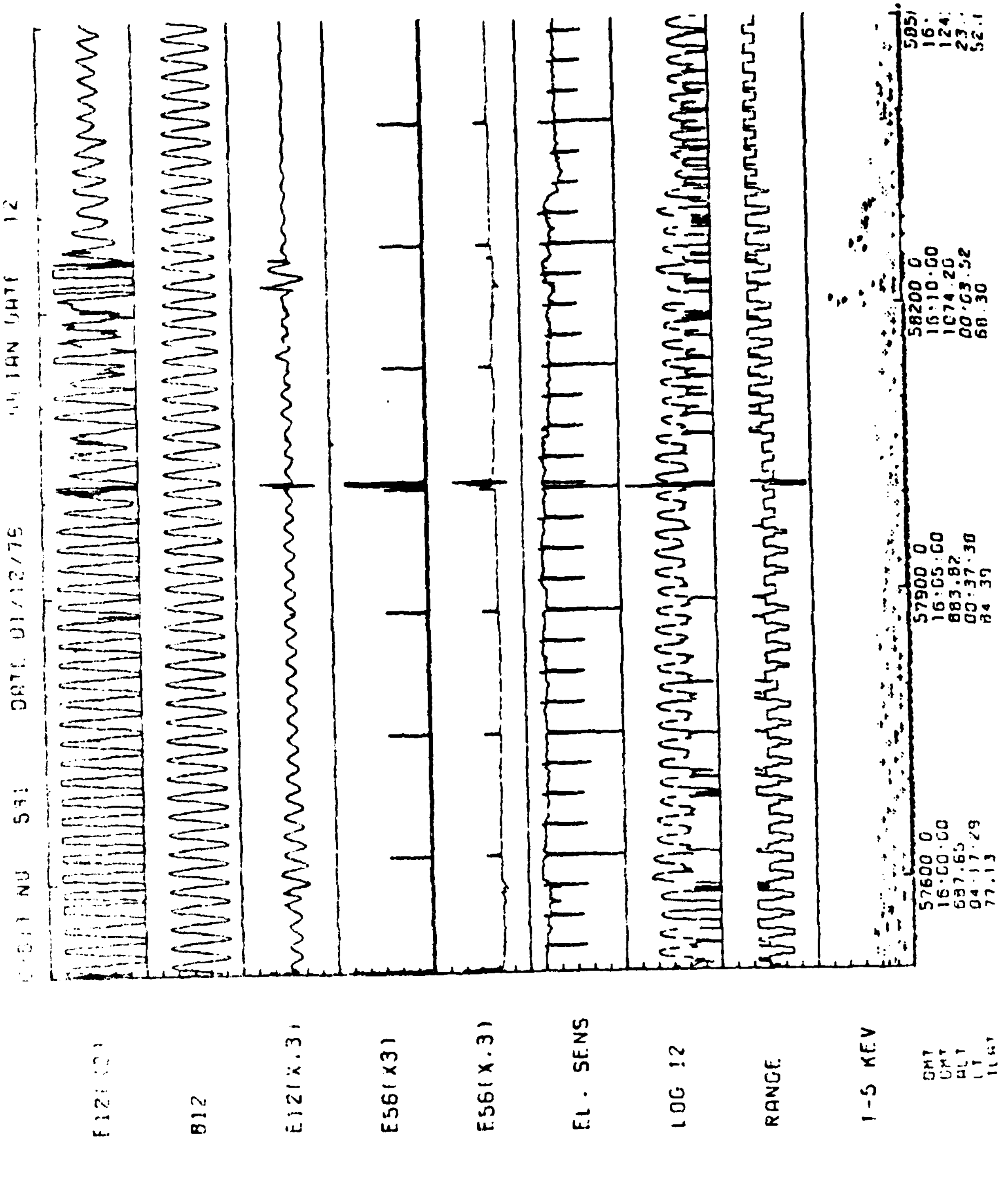


Figure 2. Sample *RAWDATA* System Plot of Data from the E-Field, Plasma Motion, and High Energy Particle Flux Experiments

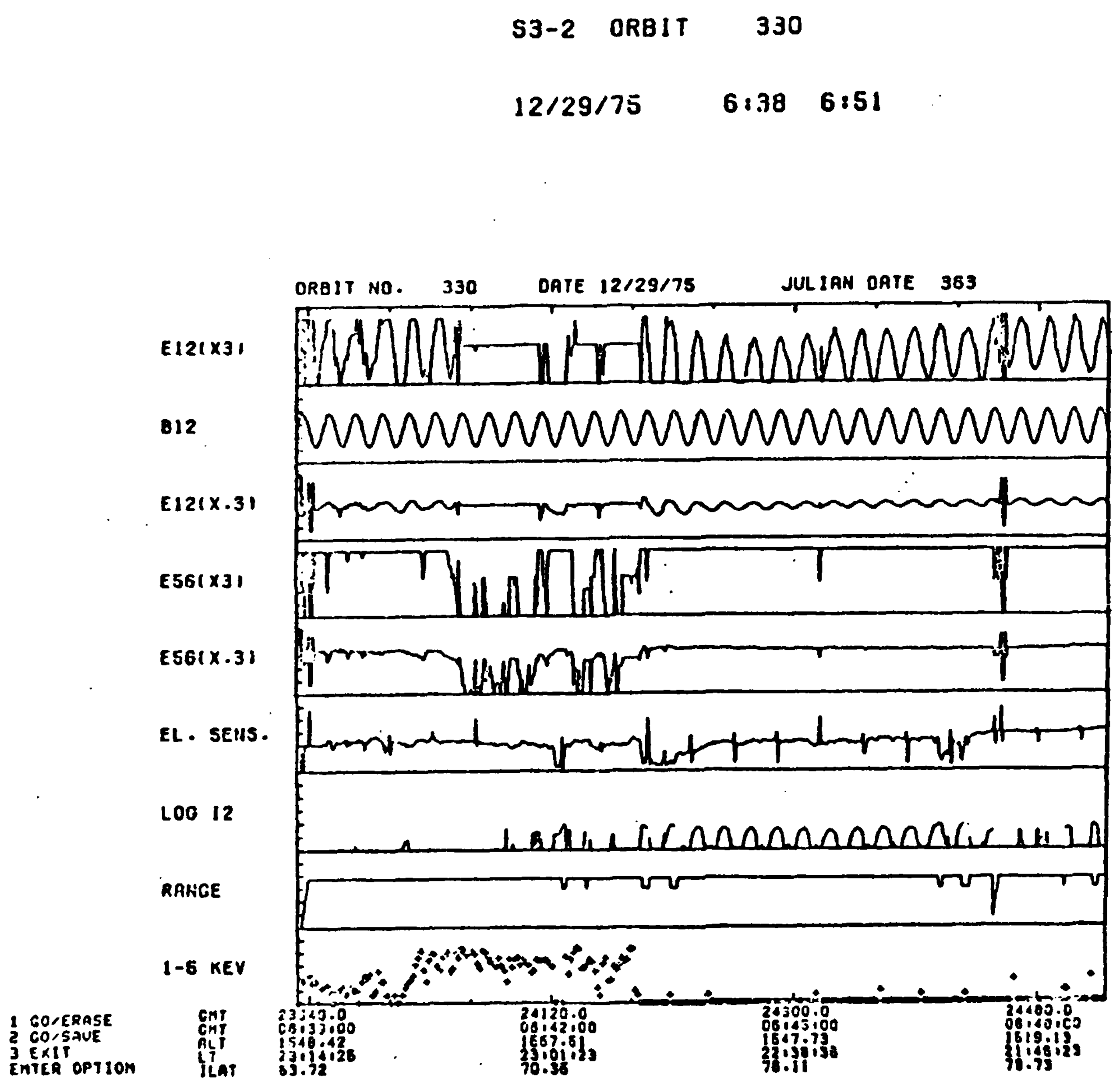


Figure 3a. Example of Microfiche/Tektronix Version of RAWDATA System Plot (with B/L Ephemeris)

S3-2 ORBIT 411

01/04/76 1:21 1:35

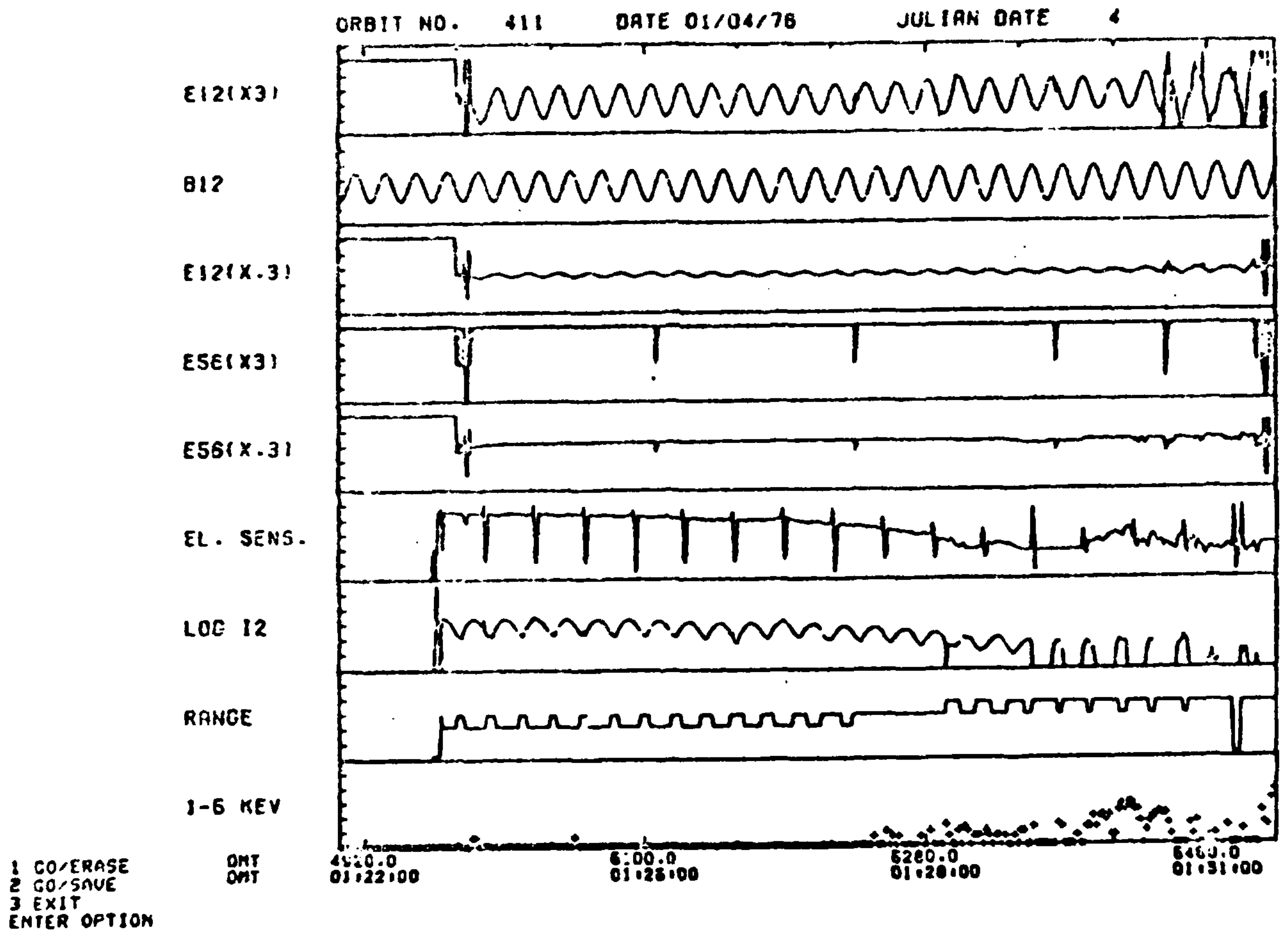


Figure 3b. Example of Microfiche/Tektronix Version of RAWDATA System Plot (without B/L Ephemeris)

2.4 Mathematical or Logical Procedures

The flow of operations within the RAWDATA System is shown in Figure 1. The program reads standard input values and initializes appropriate variables. The border with tick marks and ephemeris information is potted. Then data from the electric field, plasma, and ESA experiments is accessed, appropriately scaled, and plotted as illustrated in Figures 2 and 3.

2.5 Setup of Run-Deck

A typical run-deck is structured as follows:

```
LOBOB,T400,CM107000.
VSN, DT=V32856, OR=CC4691. RV=5056B
VSN, TAPE39=WTPLOT.
COPYCR, INPUT, PRDFL.
REWIND,PRDFL.
BEGIN,PRDRN,PRDFL,V32856,CC4691,RV=5056,AB=B.
7/8/9
RAWDATAPL (.PROC,PRDRN-----)
7/8/9
6/7/8/9
```

This run deck uses a CCL deck (.PROC,PRDRN-----) as an input source deck. The CCL deck attaches the three permanent files needed to run RAWDATA System. On the VSN card, the DT, OR, and RV parameters must be supplied in accordance with the requested REV. This applies also to the BEGIN card. Here an additional parameter, AB, must also be furnished. If there are two DT tapes for a given REV, each spanning different time segments, the earlier time is labelled A and the later time is labelled B. Thus the AB= parameter is equal to A or B if there are two DT tapes or equal to a blank if there is only one DT tape for a given REV. For example we may have two requested REV's, 2850 and 5056, with requested time segments, 00:53-01:03 and 17:40 - 17:50, respectively. Upon looking up the DT tapes for each REV, it is noticed that REV 5056 has more than one DT tape. If a REV has no time window beside it in the DT tables then there is only one tape for that REV. If there is a time window next to it, the table should be checked further to see if there is another DT tape for that REV. REV 5056 has two DT tapes assigned to it with two different window

frames: 15:44 - 16:59 for V32842 and 16:58 - 18:45 for V32856. We see that the requested time frame 17:40 - 17:50 falls into the later time frame window, which is DT=V32856. Therefore the REV is labeled B (that is, 5056B), and the AB= parameter is AB=B. If the requested time were earlier and matched the earlier time frame, we would have DT=V32842 and AB=A. In the case of REV 2850, we discover there is no time segment listed next to the REV in the DT tables. Thus we know there is only one DT tape for 2850, which is not labeled A or B; and the AB= parameter is a blank (that is, AB=   .).

2.6 Organization of Files

Table 3 is intended to provide the reader an overview of the flow of information from and into the various files utilized throughout the RAWDATA System. Note that a given file may be assigned a different name in the CCL procedure than that assigned to the same file within a program that utilizes it.

Program File Name	CCL Procedure File Name	Description
Input		
TAPE1	DT	data tape
TAPE15	DTACSIN	CCL data file containing input directives
Output		
TAPE2	DATA	copy of file from data tape
TAPE3	TAPE4	output file containing range of data
TAPE16	TPCPYOT	output tape containing tape summary

DTACS (ACSDTSR)

Program File Name	CCL Procedure File Name	Description
Input		
TAPE11	OR	ORMAG tape
TAPE3	TAPE4	range of data file (generated in DTACS as output TAPE3)
Output		
TAPE12	TAPE20	copy of file from ORMAG tape
TAPE13	TAPE13	range of ORMAG file
TAPE16	TPCPYOT	output tape receiving tape summary

ORACS (ACSORSR)

Program File Name	CCL Procedure File Name	Description
Input		
INPUT	BILD3IN	CCL input data file
TAPE1	TAPE1	data file copied from DT file #1
TAPE2	TAPE2	data file copied from DT file #2
TAPE3	TAPE3	data file copied from DT file #3
TAPE20	TAPE20	copy of file from ORMAG tape (generated in ORACS as output TAPE12)
Output		
OUTPUT	OUTPUT	print file for listing offline pen plot file

BILD3 (RAWDATAPL)

Table 3. Input/Output Flow through RAWDATA System

2.7 Error Indications

Two types of error will cause job failure. The first is the failure of the data tape and the B/L ephemeris file data spans to overlap. In this case the indication is no results in listings and plots. The tape and file numbers should be checked. The second error type is the occurrence of irrecoverable parity errors or record fragments on a magnetic tape. The tape should be cleaned and the job rerun. If the error reoccurs, the tape should be re-created.

2.8 Program Restrictions and Timing

Run time for orbit 1761 which contained 6042 seconds of data was 287 CPA seconds. A typical orbit contains 90 minutes or approximately 6000 seconds of data. As a consequence, a time limit of 400 seconds was selected as a reasonable specification on the job card.

3. STANDARD ELECTRIC FIELD System

This system demodulates the data from the spinning dipole and empirically models charging effects to yield the average ambient electric fields in quasi-local-vertical and geomagnetic coordinates. The results are tabulated and plotted.

The system consists of a number of file access and data processing programs which, if resident on the appropriate permanent files, may be loaded and accessed by a CCL procedure to perform the required tasks. The CCL procedure is, itself, a part of the overall system. A standard run deck is also available which accesses this procedure when resident on permanent file. With this deck one needs only to specify the data tapes to be used, and the period to be processed (usually one orbit).

3.1 Functional Description

A functional description of the various components of the system is presented in Table 4. Table 5 lists the programs comprising the system and the form in which they should be cataloged as permanent files. Data flow through the system is diagrammed in Figure 4.

3.2 Input

The input consists of a single punch card and three magnetic tapes. The punch card input is described in Table 6, and the tape specifications are given in Table 7. Note that if both punched card input parameters are negative the time span processed will be determined automatically by the system. The format for the DT tape can be obtained from References 3 and 4; that for the OM (attitude) tape, from References 5 and 6; and that for the ORMAG (ephemeris/magnetic field) tape, from Reference 7.

File Name of Component	Function
STANDARD ELECTRIC FIELD Processing Run Deck	Specifies data tapes required and optional specification of the time span to be processed. Default is the entire orbit. All user inputs appear in this data.
Procedure File NEWEFIELDPROC (CCL Procedure)	Provides resource allocation, program control, and standard program inputs.
ACSDTSR (Fortran Program)	Selects data file on satellite data tape by experiment name and number of the orbit on the data tape. Optionally, the header record of the required data file may be corrected. The selected file is transferred to mass storage.
ACSORSR (Fortran Program)	Selects file on B/L ephemeris tape with a time period this includes the time span of the satellite data tape. The selected file is transferred to mass storage.
ACSOMSR (Fortran Program)	Selects file on OM Attitude tape with a time period that lies within the time span of the satellite data tape. The selected file is transferred to mass storage.
ACEPTSR (Fortran Program)	Selects the maximum common time span of the data, B/L ephemeris, & OM attitude tapes.
NEFDORBITBN (Fortran Program)	Empirically fits the contact potential on the axial boom so the spurious effect may be eliminated in determining the ambient field.
NEFDEFELDBN (Fortran Program)	Processes electric field data for axial and rotating sensors. Determines field in quasilocal vertical and geomagnetic coordinates. Indicates "goodness" of fit.
NEFDLISTBN (Fortran Program)	List the results of electric field processing.
NEFDEPLOTBN (Fortran Program)	Plots the results of electric field processing.

Table 4. Functional Description of Components of STANDARD ELECTRIC FIELD System

Program Name	Form	Cataloged as PF Name
DTACS	SOURCE	*ACSDTSR
ORACS	SOURCE	*ACSORSR
OMAC	SOURCE	ACSOMSR
ACEPT	SOURCE	ACEPTSR
ORBIT	BINARY	NEFDORBITBN
EFIELD	BINARY	NEFDEFELDBN
ORBEPHL	BINARY	NEFDLISTBN
EPLOT	BINARY	NEFDEPLOTBN
EPRJRMS	SOURCE	POLARPLOTSR
PRDRN (CCLPROC)	SOURCE	NEWEFIELDPROC

* Note: Same file for RAWDATA

Table 5. Summary of Programs Comprising STANDARD ELECTRIC FIELD System

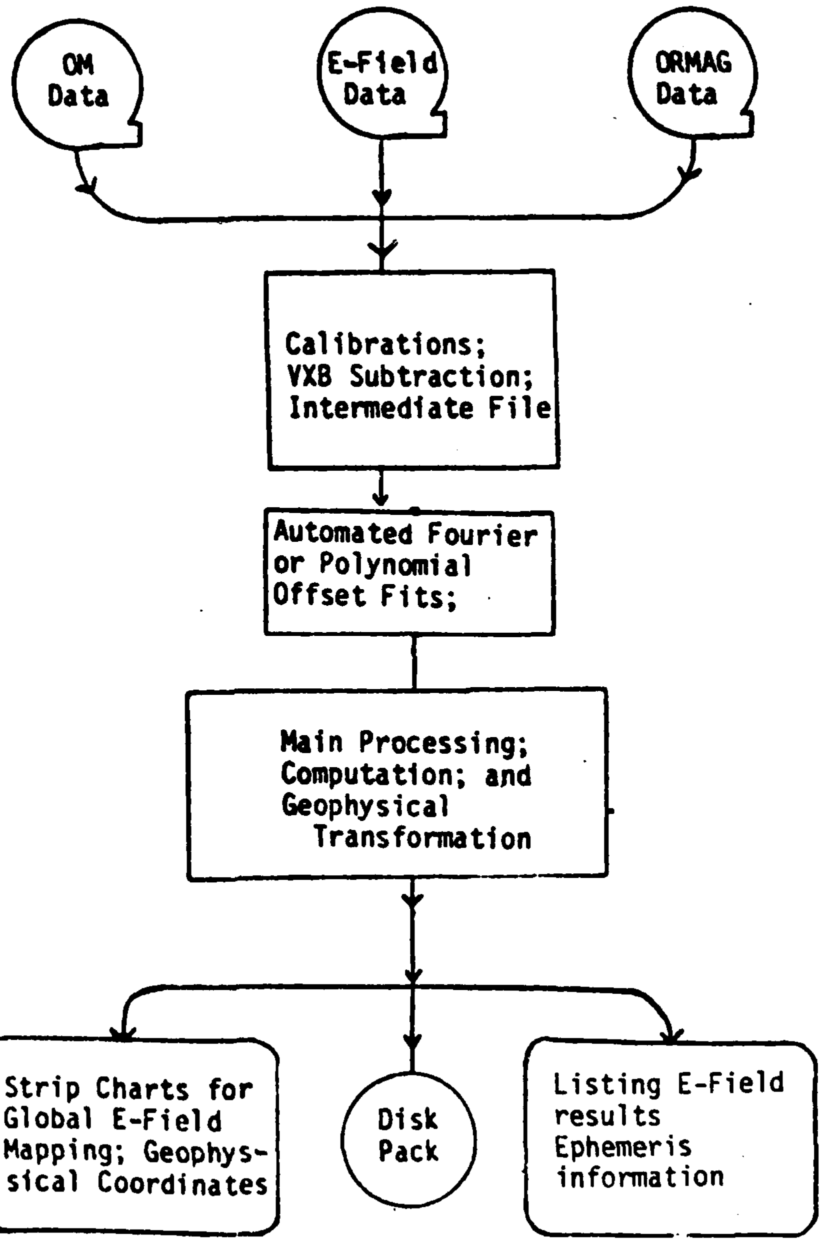


Figure 4. Flow Chart of Consolidated Program System for Electric Field Analysis

Card No.	Variable Name	Card Col.	Format	Variable Description
1	TB	n/a	Namelist "REQRNG" input	If positive, beginning time for processing (in seconds). If negative, earliest time on tape of which attitude information is available is used.
1	TE	n/a	Namelist "REQRNG" input	If positive, ending time for processing (in seconds). If negative, last time on tape for which attitude information is available is used.

Table 6. Punched Card Input for STANDARD ELECTRIC FIELD System

Logical File Name	CCL Name	Type	Label	Number of Files	Number of Records	Density	Number of Tracks	Number of Reels	Description
DT	V3XXXX	binary	no	1, level 17	488	800BPI	7	typically 1	S3-2 raw data tape
OR	CCXXXX	binary	no	1, level 0	52 word header 52 word data record	800BPI	7	1	S3-2 B/L ephemeris tape
OM	CCXXXX	coded	yes	1, level 17	variable	800BPI	7	1	S3-2 attitude tape

Table 7. Magnetic Tapes Required by STANDARD ELECTRIC FIELD System

3.3 Output

The STANDARD ELECTRIC FIELD System produces three types of output: listings, plots and permanent files. As the system has evolved, the outputs have changed to meet the varying needs of researchers who analyze the S3-2 data. Summarized here are the formats of three outputs in their current form.

3.3.1 Printed Output

Extensive printed output is provided by the system. It is summarized as follows:

Standard Electric Field Output (2 copies)

- o Banner page giving vehicle, orbit number, date of orbit (month, day, year), universal time of beginning of orbit (seconds), and experiment (EFIELD).

- o Results of processing displayed in columns with the following headings and contents:
  - Time: Universal time of datum in seconds and hours, minutes, and seconds.
  - Quasilocal-Vertical coordinates of Electric Field: Forward, up, and spin components of electric field in millivolts/meter.
  - SGNEP = Sign $(E_{fwd})*[(E_{fwd})^2 + (E_{up})^2]^{1/2}$, RMS = rms evaluation of the fit to the electric field data over three spin periods, AEPBP = angle in degrees between the projection in the spin plane of the electric and magnetic fields.
  - Geomagnetic Coordinates of Electric Field: EM1X, EM1Y, EM1Z - geomagnetic components of electric field obtained by transforming the quasilocal components described above. EM2X, EM2Y - geomagnetic components of electric field obtained by ignoring measured field along spin axis and using $E \cdot B = 0$. Thus EM2Z = 0. F is flag with following meaning: 0 denotes zero or calibrate occurred; 1 denotes $B_{spin}/B \geq 0.02$ (computation is performed as described above); 2 denotes $B_{spin}/B < 0.02$ (E_{spin} is set to zero and the field in quasilocal vertical coordinates is transformed).

Ephemeris Output (2 copies)

- Banner page giving orbit identifying information as for electric field output and the designation that following information is from the B/L ephemeris. Again this page is printed twice in the event it is desired to separate this section of the output.

- Ephemeris information is printed in columns with the following heading and contents:

  - Universal time: in seconds, and hours, minutes, seconds

  - Geographic coordinates: altitude (km.), velocity (km./sec.), geodetic latitude (degrees), longtitude (degrees), and local time (seconds).

  - Magnetic coordinates: geomagnetic latitude (degrees), geomagnetic longitude (degrees), magnetic local time (seconds), B-value (gamma), L-shell (earth radii) and invariant latitude (degrees).

- Ephemeris information is printed at one minute intervals with one hour of data per page. If a time during a particular hour is not covered by the B/L ephemeris tape, the corresponding item is indicated with dots (......).

Tape status Output (1 copy)

- Information regarding the contents and condition of the data, B/L ephemeris, and OM attitude tapes are output.

Dayfile (1 copy)

- Control Cards used in processing.

The volume of printed output can be estimated for a single copy as follows:

4 pages for day file and banner
4 pages for banner for results
1 page per five minutes of results
2 pages for ephemeris.

Since two copies are printed, the total output is twice this estimate.

3.3.2 Permanent Files

The output includes permanent files as follows:

- Permanent File RV•AB•EFLD, ID = S32NEF, SN = DPMSPW where RV is the orbit number and AB is A or B when two tapes contain the data from a given orbit or omitted if there is only one tape for the orbit. This file contains the results from program EFIELD in the following format: A six word header written in binary containing IYEAR - year of orbit, JDATE - Julian date of orbit, ONUM - orbit number, ODATE - date as MM/DD/YY, STTM - beginning time of processing in seconds, ENDTM - ending time of processing in seconds. Thirteen word "results" records written in binary containing ELV(1-3) - the electric field in quasilocal vertical coordinates, EP - signed magnitude of the projection of E in the spin plane, RMS - evaluation of the fit to the electric field over three spin periods, EM (1-3) - the electric field in geomagnetic coordinates, EM2 (1-2) - geomagnetic coordinates, assuming it is normal to magnetic field, T (I) - time of datum, AEPBP - angle in degrees between the projection in the spin plane of the electric and magnetic fields (see Section 3.3.1), IFLAG - Flag with following value:

  0 - zero or calibrate occurred
  1 - $B_{spin}/B \geq 0.02$ (computation described in Section 3.3.1)
  2 - $B_{spin}/B < 0.02$ (E_{spin} is set to zero and the field in quasi-local vertical coordinates is transformed)

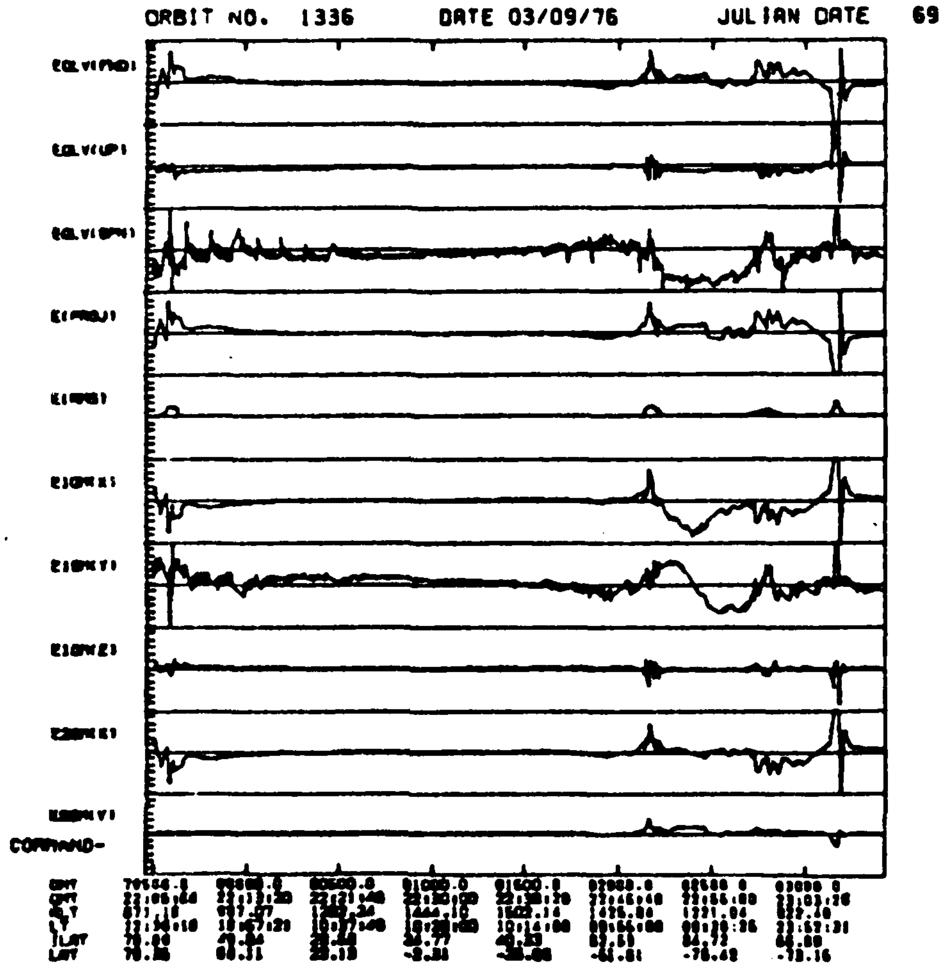


Figure 5. Typical STANDARD ELECTRIC FIELD System Plot

- Permanent File RV• ORMG, ID = S32ORMG, SN = DPMSPW where RV is the orbit number. This file contains a copy of the B/L ephemeris for the orbit. An AB identifier is normally not required since a given ephemeris file covers both the A and B portions of the orbit; if this is not the case, the AB identifier may appear in RV. Cataloging of this file is conditional upon the file not being already cataloged.

- Permanent file RV•AB• NPLT where RV is the orbit number and AB is A or B if there are two tapes for a given orbit or omitted if there is only one tape for the orbit.

These files can be used to recreate standard format plots, without the need for re-running the entire program system. In addition, there is an occasional requirement to produce a special type of display, the Polar Plot. These permanent files represent the data base from which these plots are generated. See Section 3.9.

3.3.3 Plots

Perhaps the most important type of output from the processing operation is the graphical plot, an example of which is shown in Figure 5.

Quantities plotted are the following:

- Y-Axis: E-field components in quasi-local vertical system (forward, up, spin); projected E-feld, rms measure of "goodness of fit"; X, Y, and Z components of E-field in geomagnetic coordinate system; E-field component in geomagnetic coordinates ignoring spin component and assuming $\bar{E} \cdot \bar{B} = 0$.

- X-Axis: Universal time in both total seconds and hours/minutes/seconds; Vehicle location in terms of altitude (km), local time (hours/minutes/seconds), and latitude (degrees).

Plots can be obtained online, offline, and with the Tektronix/Microfiche systems.

3.4 Methods of Analysis

The orbit of the vehicle and nature of the electric field experiment has been described in the introduction. This experiment operates in a repetitive 512 - sec cycle that begins with a 10 - sec calibrate sequence. The probes at the ends of the booms are shorted to satellite ground for one second intervals beginning at 128, 256, and 384 seconds into the cycle. Data from the axial and rotational booms are collected 32 times per second except for one of the high gain rotational booms that is sampled at 64 times a second.

3.4.1 ORBIT

Program ORBIT determines the DC-offset for the axial boom in the following fashion. For lower latitudes (<60°) where the Earth's magnetic field lines are closed, the ambient electric field is vanishingly small because of the lack of solar wind induced effects mapping down along open magnetic field lines. Therefore, any voltage that remains after subtraction of the induced field ($\bar{v} \times \bar{B}$) can be attributed to the DC-offset on the axial boom. For regions below 60° geodetic latitude, this residual voltage is fit to a slowly varying function which has a period corresponding to the satellite's orbital rate of rotation, w_0:

$$V(t) = B_1 \sin w_0 t + B_2 \cos w_0 t + B_3.$$

One sample per second in the desired region is selected for this fit with points occurring during the calibrates and zeroes being eliminated. Immediately after a calibration sequence, the satellite data shows an exponential decay from the maximum measurable voltage. To account for this, if the absolute value of the voltage obained after subtracting the induced field is greater than 1.60 volts, this datum is replaced by 1.60 volts with the appropriate sign.

A flow chart for ORBIT is provided in Figure 6.

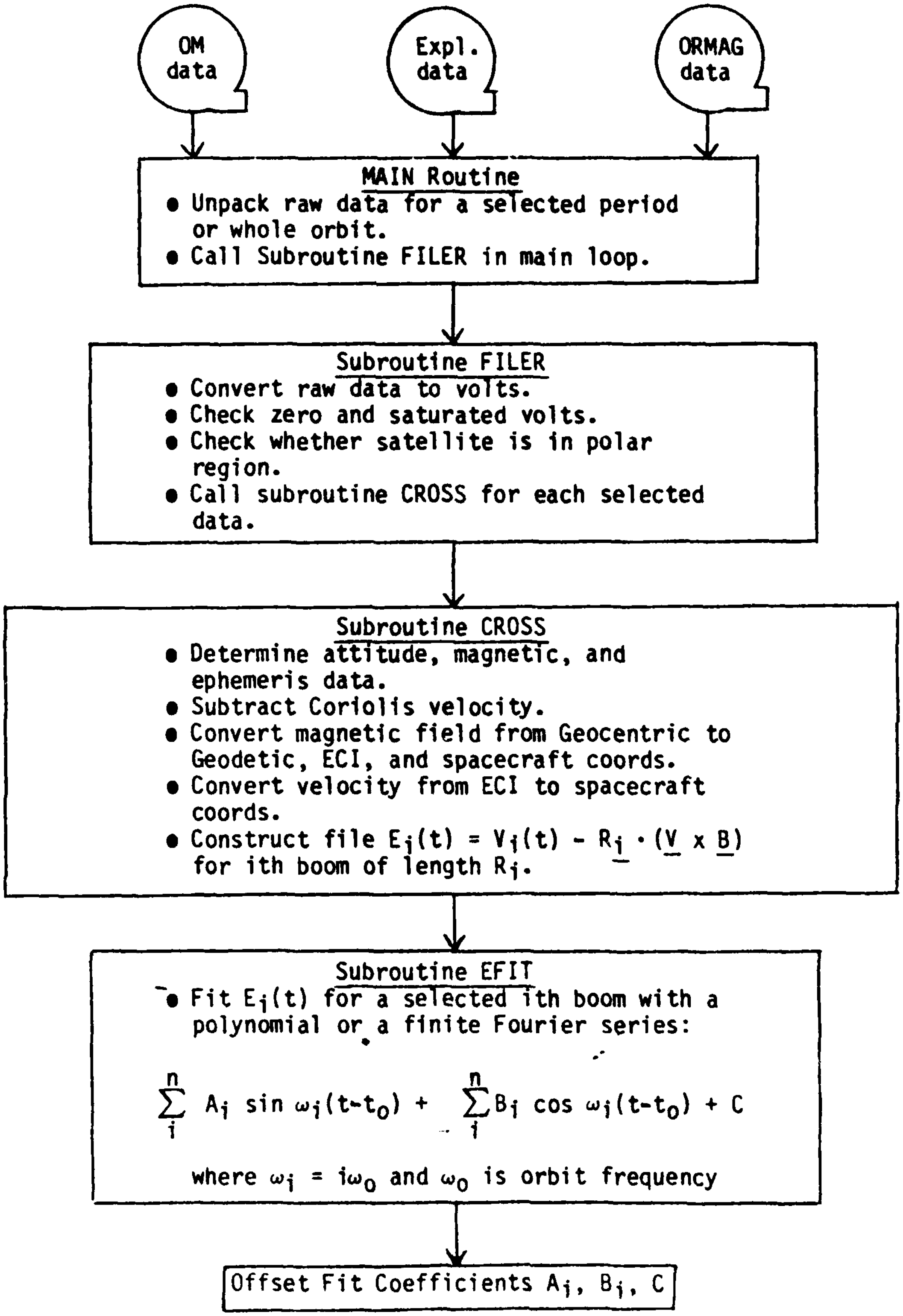


Figure 6. Flow Chart for the Functional Description of Program ORBIT

3.4.2 EFIELD

Program EFIELD determines the ambient electric field observed by the satellite and presents these results in quasilocal-vertical, earth-centered inertial, and geomagnetic coordinates. A flow chart for EFIELD is presented in Figure 7. Initial processing unpacks the raw data file, recognizes data words, converts data to raw voltages by the appropriate amplifiers gain, removes amplifier bias, and eliminates calibration and zeroing sequences.

For the rotating sensor, the electric field is determined by a least squares fit of the spinning boom voltage to a function of the form:

$$V(t) = A(t) \sin (w_s t) + B(t) \cos (w_s t) + C(t).$$

A(t) and B(t) are linear combinations of the first five Chebyshev polynomials and C(t) is a linear combination of the first three Chebyshev polynomials; the coefficients of these linear combinations are determined by the least squares fit. Three spin periods are chosen for the fit span with data sampled four times per second. The voltage measured is:

$$V(t) = E(t) \cdot r(t), \text{ where } r(t) = r_0(\sin(w_s t)\, x + \cos(w_s t) y).$$

A(t) and B(t) are the x and y components of E in the spin plane, expressed in a non-rotating coordinate system whose y-axis coincides with the spinning boom at t=0. C(t) represents the DC offset.

The above analysis yields the measured field if the ambient electric field and DC offset vary with a characteristic time which is longer than the spin frequency. If the ambient electric field varies more rapidly this analysis yields an average value for the field.

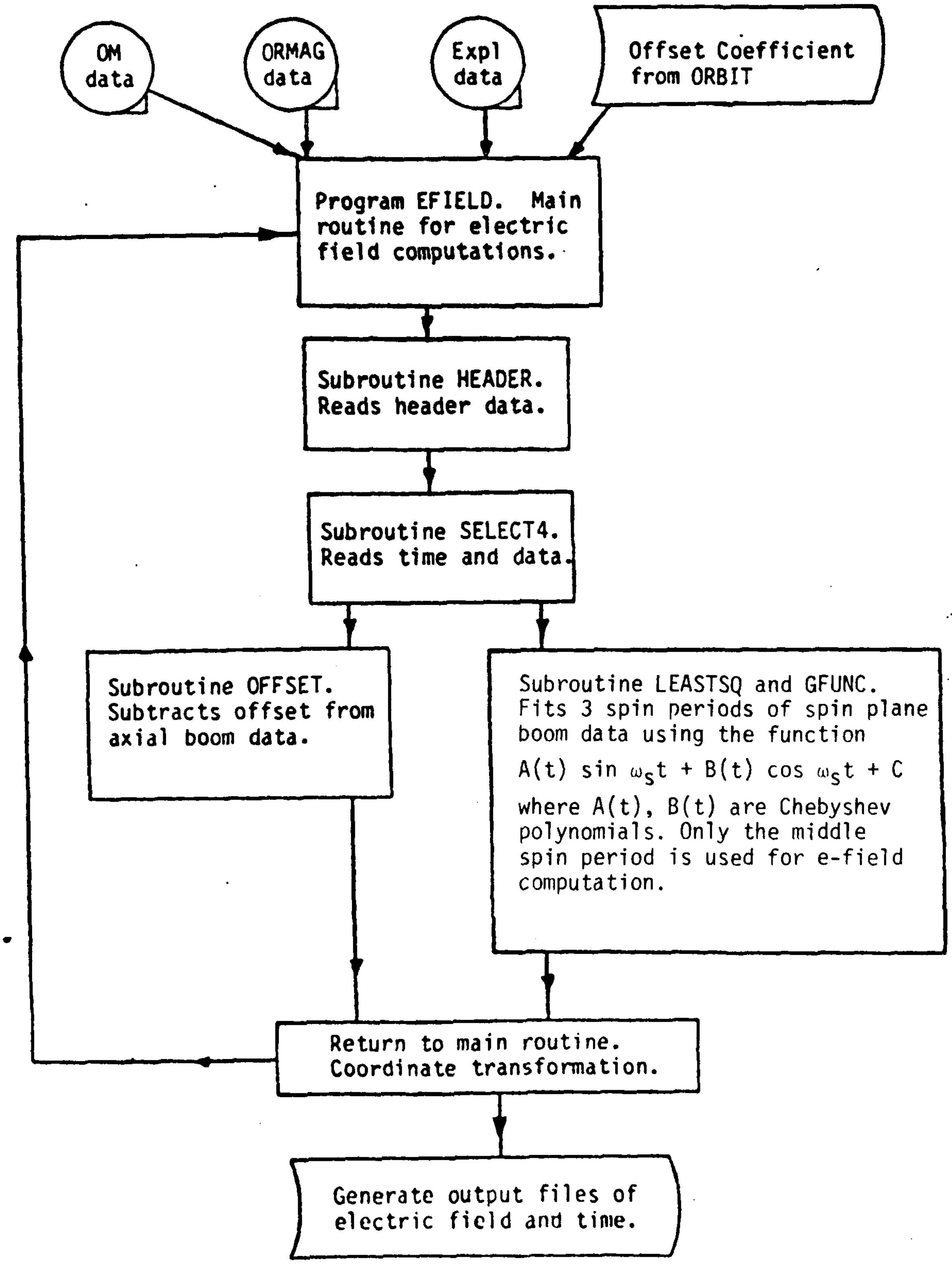


Figure 7. Flow Chart for the Functional Description of Program EFIELD

The predominant field measured is the induced field ($\bar{v}x\bar{B}$), where $\bar{v}$ is the relative velocity of the satellite and $\bar{B}$ is the Earth's magnetic field. The corotation velocity ($\bar{W}_e x\bar{R}$) of the magnetic field lines must also be taken into account. Thus,

$$\bar{E}_{true} = \bar{E}_{meas} - (\bar{v}_S - \bar{W}_e x \bar{R}) \times \bar{B}$$

where $\bar{W}_e$ is the Earth's rotational angular velocity, v_s is the velocity of the satellite in the inertial reference frame, and R is the position vector of the spacecraft measured from the center of the earth. This subtraction is performed for the central third of the fit span of three spin periods. The true, or ambient field is computed at 5 second intervals in the various coordinate systems.

For the axial boom, the DC offset determined by program ORBIT and the induced field are both subtracted from the measured voltage. Values are determined at 5 second intervals for the various coordinate systems.

Recent modifications to Program EFIELD provide the capability to perform the following computations:

$$E_p = \text{sign}\ [(E_{fwd})^2 + (E_{up})^2]^{1/2}$$

Angle EPBP = angle with spin plane between the projection of E and B.

$$\text{RMS} = \text{SQRT}\left[\frac{\sum\limits_{\substack{3\ \text{spin}\\ \text{periods}}} \left(V_{meas} - \bar{r}.\ (\bar{v}x\bar{B}) - E_p \ell \sin w_s t\right)_i}{\ell \sum\limits_{\substack{3\ \text{spin}\\ \text{periods}}} 1}\right]$$

$$\begin{bmatrix} E_{x2m} \\ E_{y2m} \\ E_{z2m} \end{bmatrix} = \begin{bmatrix} M \end{bmatrix} \times \begin{bmatrix} E_{fwd} \\ E_{up} \\ E_{calculated} \end{bmatrix}$$

where

ℓ = length of spinning boom

M is the transformation from quasilocal vertical to geomagnetic coordinates,

$E_{calculated} = (E_{fwd} B_{fwd} + E_{up} B_{up}) / B_{spin}$ if $B_{spin}/B \geq 0.02$

and

$E_{calculated} = 0$ if $B_{spin}/B < 0.02$

The results of Program EFIELD are written to a permanent file as described in section 3.3.

3.4.3 ORBEPHL

Program ORBEPHL lists the results written to permanent file and also lists relevant ephemeris information.

3.4.4 EPLOT Program EPLOT plots the results written to permanent file by program EFIELD. A border with ephemeris information is provided.

3.5 Run Deck

The run deck for the STANDARD ELECTRIC FIELD System is structured as follows:

```
LOBOB,T300,CM100000,MTI,PK.
MOUNT,VSN=PLSEFD,SN=DPMSPW.
VSN,DT=V32195,OR=CC3104,OM=CC0285.
COPYCR,INPUT,PRDFL.
REWIND,PRDFL.
BEGIN,PRDRN,PRDFL,V32195,CC3104,CC0285,RV=1338,AB= ,TB=-1,TE=-1.
7/8/9
.PROC,PRDRN-------
6/7/8/9
```

This run deck uses NEWEFIELDPROC as an input source deck. The DT, OR, OM and RV parameters must change for each new job. If an RV is specified as A or B, then the BEGIN card must have AB=A, (or B if that is the case). If the RV parameter does not specify A or B, leave the space after the = sign blank (viz, AB= ,). Also, this job can be run by using NEWEFIELDPROC as an attached file and copying it to the PRDFL file:

```
ATTACH, AA, NEWEFIELDPROC, ID=GEDDES.
COPYCR, AA, PRDFL.
```

The system will catalog a file with the REV# followed by the letters NPLT (e.g., 4652A will give 4652ANPLT; 1338 will give 1338NPLT). This perm-file is a data file for a Tektronix plot. The plot is generated using the following Tektronix commands:

```
ATTACH,AA, 1338NPLT, ID=GEDDES
CONNECT, OUTPUT
COPYBF,AA,OUTPUT,2
```

At the same time the system will catalog two files on diskpack SN=DPMSPW, VSN=PLSEFD. They are 1338EFLD, ID=S32NEF and 1338ORMG, ID=S32ORMG.

3.6 Organization of Files

Table 8 is intended to provide the reader an overview of the flow of information from and into the various files utilized throughout the STANDARD ELECTRIC FIELD System. Note that a given file may be assigned a different name in the CCL procedure than that assigned to the same file within a program that utilizes it.

3.7 Error Indications

Two types of error are the most frequent causes of job failure. The first is failure to achieve overlap among the data spans covered by the raw data, the B/L ephemeris, and the OM attitude tapes. The indication of this error mode is to have no results in the listings or plots. The tape and file numbers should be checked.

The second type of error is occurrence of irrecoverable parity errors or record fragments on one or more tapes. The indications is a message in the dayfile. The tape should be cleaned and the job rerun. If the failure recurs, the tape should be recreated.

Program File Name	CCL Procedure File Name	Description
Input		
TAPE1	DT	data tape
TAPE15	DTACSIN	CCL data file containing input directions
Output		
TAPE2	DATA	copy of file from data tape
TAPE3	TAPE3	output file containing range of data
TAPE16	TPCPYOT	output tape containing tape summary

DTACS (ACSDTSR)

Program File Name	CCL Procedure File Name	Description
Input		
TAPE11	OR	ORMAG tape
TAPE3	TAPE3	range of data file (generated in DTACS as output TAPE3)
Output		
TAPE12	ORMG	copy of file from ORMAG tape
TAPE13	TAPE13	range of ORMAG file
TAPE15	TPCPYOT	output tape receiving tape summary

ORACS (ACSORSR)

Table 8a. Input/Output Flow through STANDARD ELECTRIC FIELD System

Program File Name	CCL Procedure File Name	Description
Input		
TAPE21	OM	OM tape
TAPE3	TAPE3	range of data tape (generated in DTACS as TAPE3)
Output		
TAPE22	OMOM	copy of file from OM tape
TAPE23	TAPE23	range of OM file
TAPE16	TPCPYOT	tape receiving tape summary
TAPE26	TAPE26	receives error allowed in ERRSET

OMACS

Program File Name	CCL Procedure File Name	Description
Input		
INPUT	RNGIN	CCL data file namelist read data range (generated in DTACS as TAPE3)
TAPE3	TAPE3	
TAPE13	TAPE13	ORMAG range (generated in ORACS as TAPE13)
TAPE23	TAPE23	OM range (generated in OMACS as TAPE23)
Output		
TAPE15	TAPE15	namelist output of stop and start times
OUTPUT	ACEPTOT	output of stop and start times

ACEPT

Table 8b. Input/Output Flow through STANDARD ELECTRIC FIELD System (continued)

Program File Name	CCL Procedure File Name	Description
Input		
TAPE1	DATA	Data tape file
TAPE5	ORBITIN	CCL data file (coefficents for conversion of Efield data generated by a calibration)
TAPE2	ORMG	ORMAG Tape file
TAPE4	OMOM	OM Tape file
TAPE15	TAPE15	Namelist file containing start and stop times to be read that were generated as TAPE15 in RANGE
Output		
TAPE17	ORBT17	Fourier fit coefficient normalizing Efield data to (VXB) for sensor scale factor and bias corrections
TAPE6	ORBTOT	Listed output
TAPE3	ORBTO3	Orbit file to be created

ORBIT

Program File Name	CCL Procedure File Name	Description
Input		
TAPE5	EFIN	CCL data file input
TAPE10	OMOM	OMOM tape file
TAPE20	ORMG	ORMAG tape file
TAPE30	DATA	DATA tape file
TAPE17	ORBT17	Fourier fit coefficient normalizing Efield data to (VXB) for sensors scale factor and bias corrections
TAPE15	TAPE15	Namelist file containing start and stop times to be read that were generated as TAPE15 in RANGE
TAPE2	EF02	Data tape file (generated in DTACS as output TAPE2)
Output		
TAPE6	EFOT	Listed output
TAPE2	EF02	Not used
TAPE12	EF12	Header and NEFD information
TAPE26	EF26	Diagnostic output listing contents of tape 12

Note. AA is copied from EF12 and cataloged as RV•EFLD on private disk pack. AA is then returned. Then AA is copied from ORMG and cataloged as RV•ORMG on private disk pack.

EFIELD

Table 8c. Input/Output Flow through STANDARD ELECTRIC FIELD SYSTEM (Continued)

Program File Name	CCL Procedure File Name	Description
Input		
TAPE5	LISTIN	CCL input data file (contains orbit# RV·AB)
TAPE1	EF12	attached RV·AB·EFLD file (cataloged in EFIELD, see note to EFIELD)
TAPE2	ORMG	attached RV·ORMG file (cataloged in EFIELD, see note to EFIELD)
Output		
TAPE6	LISTER	output listing
TAPE16	LISTOT	output TAPE (used to suppress ORMAG error messages)

ORBEPHL

Program File Name	CCL Procedure File Name	Description
Input		
INPUT	EPLOTIN	AORB = section of orbit Blank = repeat plot/ other characteristics
TAPE1	EF12	Permanent file RV·AB·EFLD (generated as AA in program EFIELD and copied to pf with ID RV·AB·EFLD)
TAPE20	ORMG	Permanent file RV·ORMG (generated in program EFIELD and copied to pf RV·ORMG)
Output		
T40140	RV·AB·NPLT	Plot file for Tektronix plot

EPLOT

Table 8d. Input/Output Flow through STANDARD ELECTRIC FIELD SYSTEM (continued)

3.8 Computer System Requirements

For twenty randomly selected orbits, the average program performance was 1[illegible].2 CPA sec per 1000 seconds of data. The maximum time required was 21.1 CPA sec per 1000 seconds of data and the minimum time was 16.0 CPA sec per 1000 seconds of data. Thus 200 to 300 seconds is reasonable estimate of run time for the maximum length data span of approximately 2 hours.

One tape drive is required for operation of this system. It uses 110K octal core memory.

3.9 Special Plotting Capabilities

As noted in Section 3.3, the system creates two output files which are cataloged on disk pack SN=DPMSPW, VSN=PLSEFD. For REV 1338, for example, these files are denoted 1338EFLD, ID=S32NEF and 1338ORMG, ID=S32ORMG.

For special situations researchers require plots of EP and RMS (see Section 3.4) for those portions of orbits during which the vehicle is at polar latitudes. The criterion employed is invariant latitude $\geq 50°$ north or $\geq 50°$ south. Online, offline, or Tektronix plots of this type can be generated using run deck POLARSTRIP CHART. An example of this type of plot is shown in Figure 8. The continuous plot represents EP; the prints represented by symbols represent RMS.

The job control cards required for a POLARSTRIP run as follows:

```
LOBOB,PK,T300.
MOUNT,VSN=PLSEFD, SN=DPMSPW.
ATTACH,PEN, ONLINEPEN.
LIBRARY, PEN.
SWITCH, 2.
COPYCR, INPUT, AA.
REWIND, AA
BEGIN, PJRMPC, AA, RV=1338, AB= .
7/8/9
.PROC,PJRMPC -----
7/8/9
6/7/8/9
```

As indicated, this run deck utilizes a CCL deck (.PROC, PJRMPC----) as source input. The only parameters to be changed are the BEGIN card: RV and AB. (Notice that the AB parameter is followed by either an A,B or a blank).

A run deck, "PROC TO REPLOT AND LIST NEFD," is available to plot and list data contained in the two files created by the system on the disk pack SN=DPMSPW, VSN=PLSEFD. For REV 1338 these files would be designated 1338EFLD, ID=S32NEF and 1338ORMG, ID=S32ORMG. The routine, which will create and catalog a file 1338NPLT for plotting by the Tektronix, is used whenever plots and/or listings are requested for a REV already processed by the system. Job control cards for this operation are as follows:

```
LOBOB, STMPK.
MOUNT, VSN = PLSEFD, SN=DPMSW.
COPYCR, INPUT, AA.
REWIND, AA.
BEGIN, PJRMPC, AA, RV = 10449, AB = B.
7/8/9
.PROC, PJRMPC -------
.
.
.
.
6/7/8/9
```

where .PROC, PJRMPC ------- is a CCL deck which attaches the RV·AB·EFLD and RV·ORMG file from disk pack and runs programs ORBEPHL to list what is on those files and program EPLOT to create permanent file RV·AB·NPLT for a Tektronix plot.

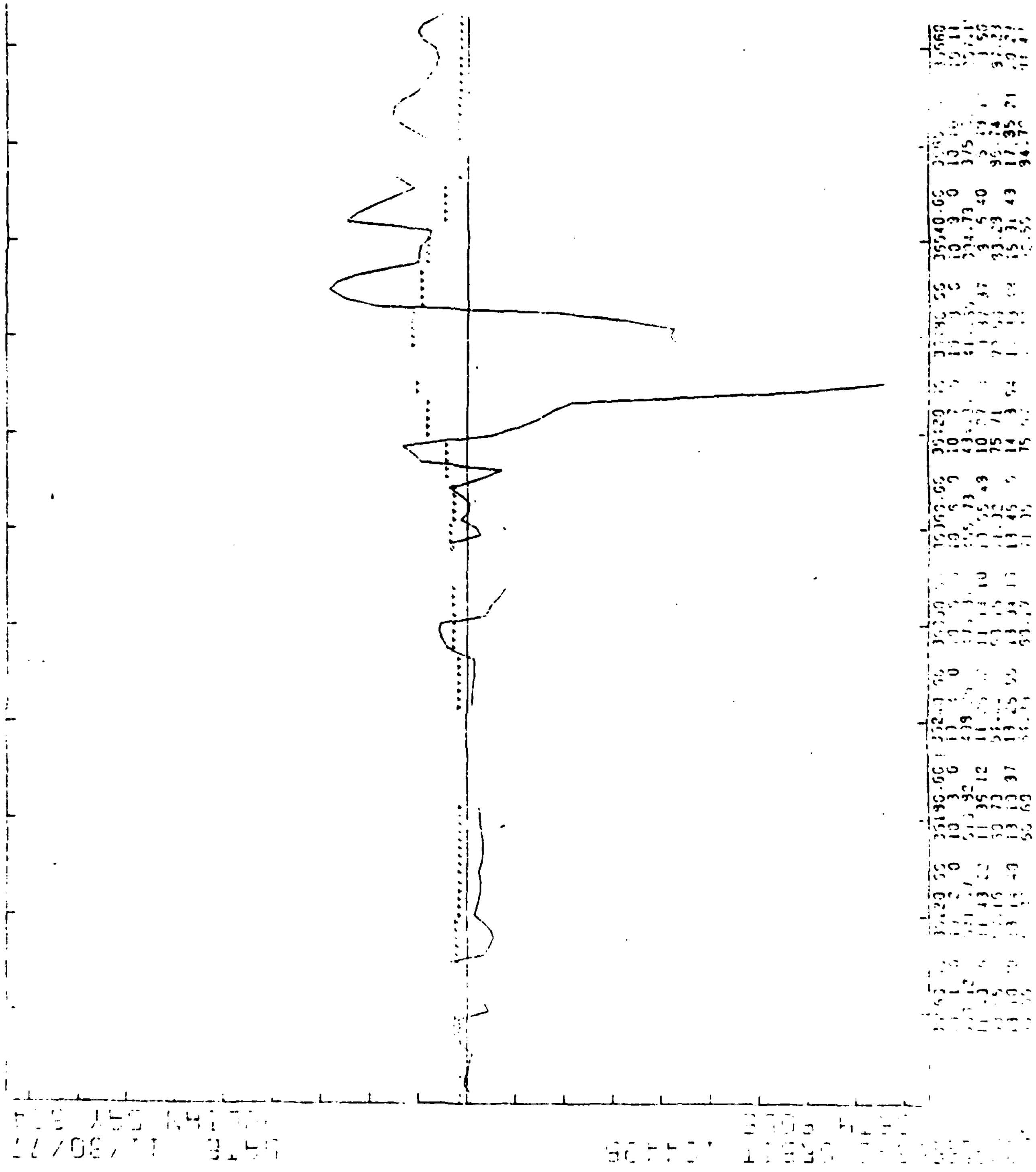


Figure 8. Example of a POLARSTRIP Plot for the North Pole for Orbit 10449B

4.0 DETAILED PROCESSING System

Having covered Sections 2 and 3, the reader will have observed that RAWDATA and STANDARD PROCESSING represent opposite extremes from the point of view of depth of analysis of the electric field data:

- RAWDATA System literally presents the raw data from the electric field sensors (together with raw data from other sensors)

- STANDARD PROCESSING corrects the raw measurements for environmental and motion-induced effects to obtain true ambient fields. These are smoothed and converted to a variety of coordinate systems useful for interpretation of the measurements.

The DETAILED PROCESSING System performs an analysis of the electric field measurements that, with respect to depth, is intermediate to these systems. Raw data is taken from a selected channel (i.e., a specific boom/gain combination) and is corrected for motion-induced effects to obtain the corresponding component of the ambient field. The results are listed and plotted.

The results of the processing are also available as output files into which the data have been packed efficiently using utility routines which capitalize on the limited dynamic range of the data to store multiple data words in each 60 bit CDC word.

4.1 Functional Description

The DETAILED PROCESSING System divides into two basic modules. The processing module accesses the raw data tape for an S3-2 orbit, computes the motional electric field resulting from the vehicle's motion in the Earth's magnetic field, and packs this information with an appropriate header in a file which is cataloged for further use. The B/L - ephemeris used in this processing is also cataloged. Figure 9 illustrates the functional flow of the processing module. Table 9 lists the components of this module and their functions. The packing/unpacking routine PACKUP used in this module is a utility routine described elsewhere[2].

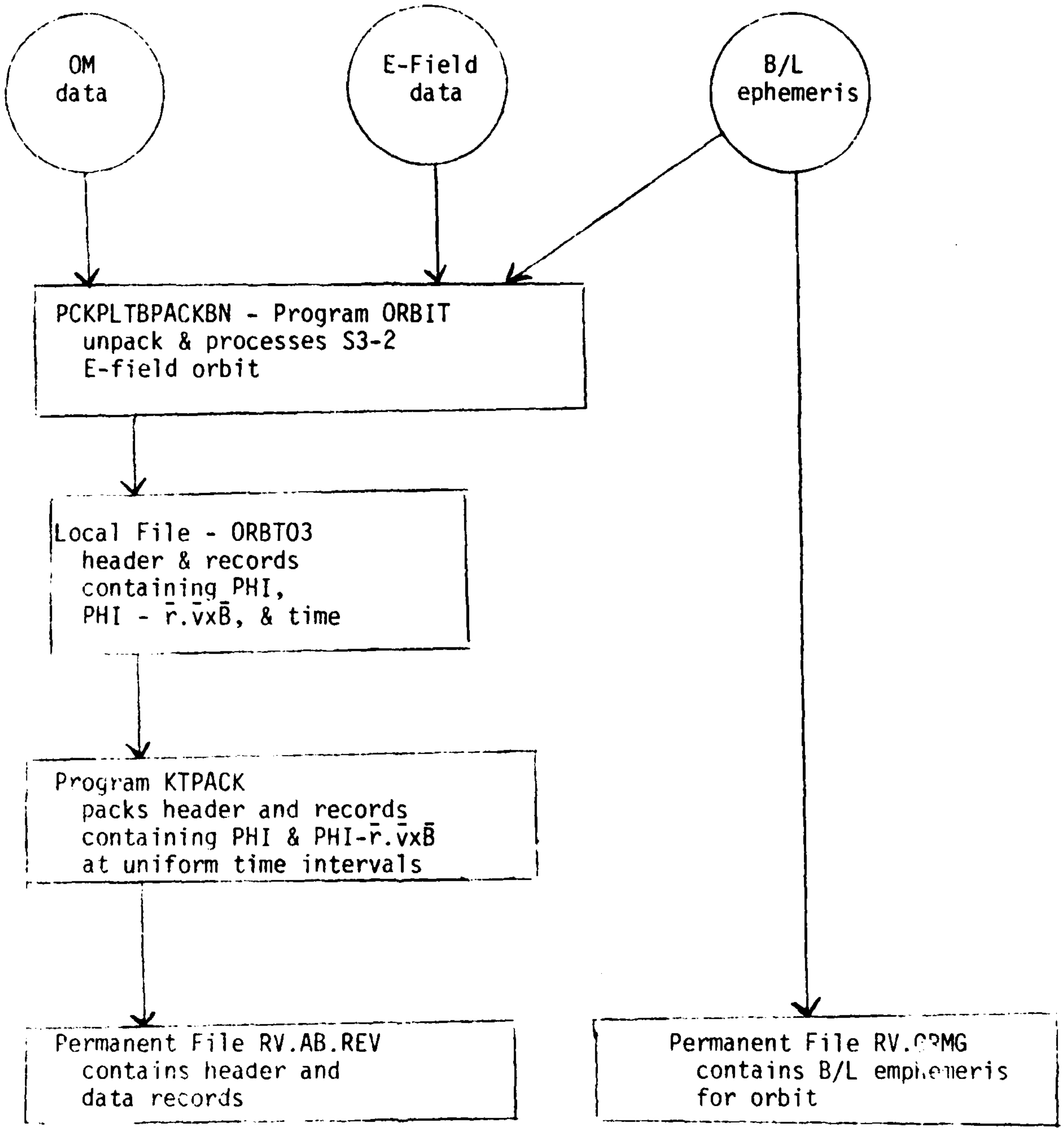


Figure 9. Operation of Processing Module

File Name	Function
Processing Module Run deck.	Specifies the S3-2 data tape, B/L ephemeris tape, and OM attitude tape and the files used on these tapes. Time span to be processed, the experiment channel, and the number of points per second are also given.
PCKPLTBPACKPC (CCL procedure, & Fortran Program)	Provides resource allocation, program control, and standard program inputs. The packing program KTPACK written in Fortran also appears in this deck.
ACCESSPC (CCL Procedure)	Governs access to data tapes and selection of proper files.
PCKPLTPACKUPBN (Fortran Subroutine)	Utility packing/unpacking routine
PCKPLTBPACKBN (Fortran Program)	Unpacks satellite data tape, converts from telemetry units to volts, computes motional electric field ($\bar{r} \cdot \bar{v} x \bar{B}$ where $\bar{r}$ = vector along sensor, $\bar{v}$ = velocity of vehicle, $\bar{B}$ = Earth's magnetic field).

Table 9. Components of Processing Module and their Functions.

It should be emphasized that program ORBIT used in this system is a scaled-down version of the program ORBIT used in the STANDARD ELECTRIC FIELD system. The two versions are not interchangeable.

The plotting module provides online, offline, or Tektronix plots of the measured electric field component, the corresponding motional electric field component, and ambient electric field component observed by a selected dipole antenna on the S3-2 vehicle. Listing of the data may be provided in conjunction with or independently of the plotting. Figure 10 illustrates the functional flow of the plotting module. Table 10 lists the components of this module and their functions.

Table 11 lists the component programs used within the DETAILED PROCESSING System, together with the form in which they are used and their permanent file names.

File Name	Function
Plotting Module Run deck	Specifies permanent file produced by processing module; gives time period & scales of plots.
PCKPLTBPLOTPC (CCL procedure)	Accesses user programs and plotting libraries, provides program control and standard inputs.
PCKPLTUNPCKPL (Fortran program in UPDATE form)	Unpacks permanent file produced by processing module. Optionally lists contents of file and experiment conditions.
PCKPLTBPLOTPL (Fortran program in UPDATE form)	Plots "PHI" - the measured electric field, "$\bar{r}\cdot\bar{v}x\bar{B}$" - the motional electric field, and "PHI - $\bar{r}\cdot\bar{v}x\bar{B}$" - the ambient electric field. The strip chart includes a border with ephemeris information.

Table 10. Components of Plotting Module and their Functions.

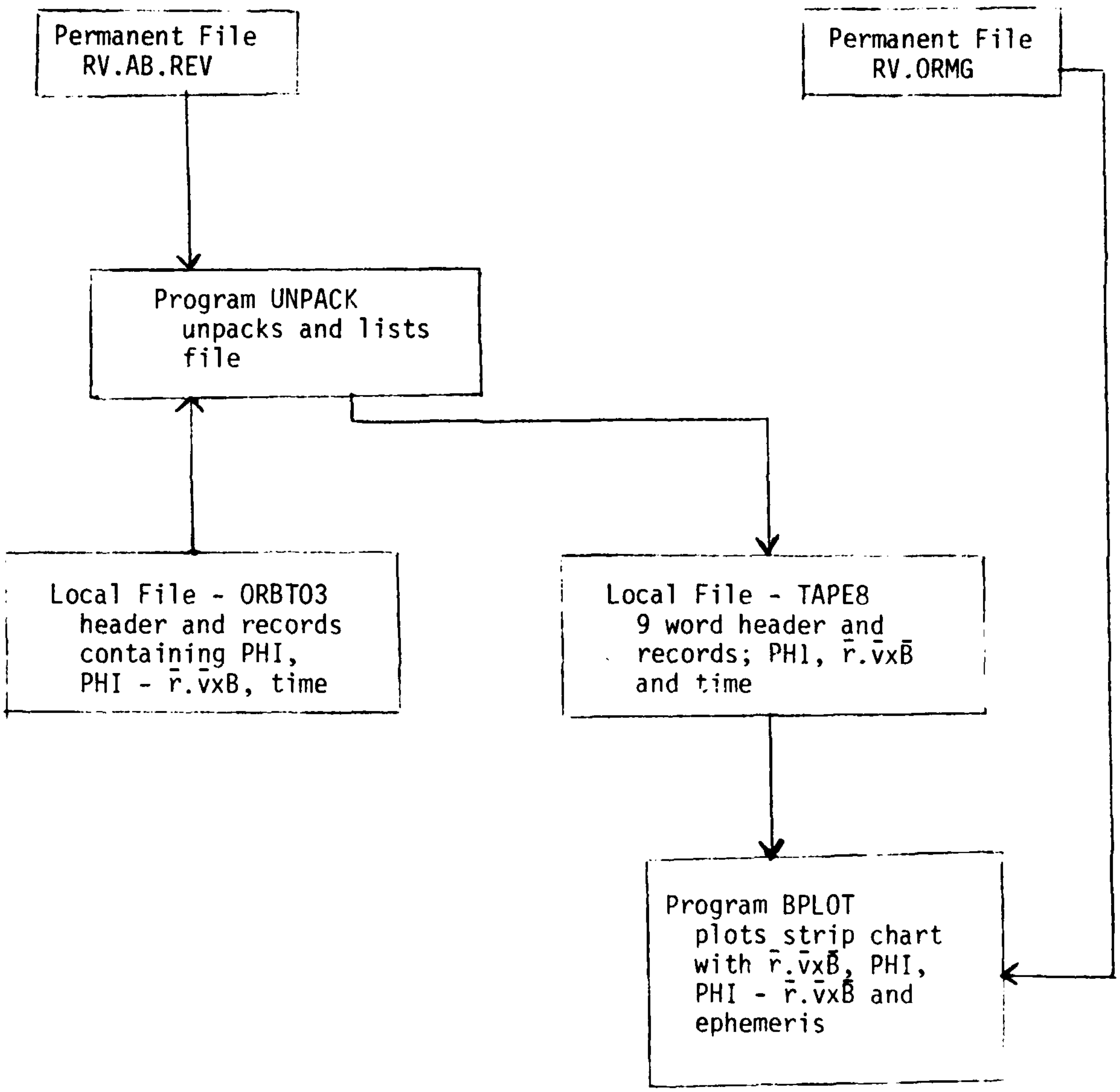


Figure 10. Operation of Plotting Module

Program Name	Form	Cataloged as PF Name
ACSPC	SOURCE	ACCESSPC
ORBIT	BINARY	PCKPLTBPACKBN
UNPACK	UPDATE	PCKPLTUNPCKPL
PACKUP	BINARY	PCKPLTPACKUPBN
BPLOT	UPDATE	PCKPLTBPLOTPC
PRDRN#1	SOURCE	PCKPLTBPACKPC
PRDRN#2	SOURCE	PCKPLTBPLOTPC

Table 11. Program Files for the DETAILED PROCESSING System

4.2 Input

Six channels of E-Field data are available at the output of the telemetry system as summarized in Table 12. Maximum data rates are given in samples per second. Maximum data rates are given in samples per second.

Channel #	Boom	Status	Amplifier	Max. Data Rate	Approximate Voltage range
1	rotating	operational	high gain	64	±0.8V
2	rotating	nonoperational	"	32	"
3	axial	operational	"	32	"
4	rotating	operational	low gain	32	±8.0V
5	rotating	nonoperational	"	32	"
6	axial	operational	"	32	"

Table 12. S3-2 Channel Allocations

A major decision that must be made and inputted to the processing system is choice of channel. Most processing is done on channels 4 and 6 at the maximum data rate. Channel 1 can provide useful data at the higher rate, but clipping often occurs due to saturation of the amplifier. Channel 3 is almost always saturated except for short periods during an equatorial crossing when the motional electric field changes sign. The rotating boom corresponding to channels 2 and 5 failed to deploy; no data is available from these channels.

Input to the DETAILED PROCESSING System consists of punched cards, permanent files, and magnetic tapes, as described in the following sections.

4.2.1 Punched Cards

Tables 13 and 14 summarize the card inputs to the processing and plotting modules, respectively.

Card No.	Variable Name	Card Col.	Format	Variable Description
1	TB	n/a	Namelist "REQRNG"	Beginning time for processing (in seconds).
1	TE	n/a	"	Ending time for processing (in seconds).
1	IC	n/a	"	Channel for which electric field data is processed (see Table 12 for Channel designation).
1	NP	n/a	"	Number of data points per second to be produced (see Table 12 for maximum data rate for a given channel; NP must be a divisor of the maximum data rate).

Table 13. Punched Card Input for PROCESSING MODULE

Card No.	Variable Name	Card Col.	Format	Variable Description	Default
1	TB	n/a	NAMELIST "REQRNG" for program UNPACK	Beginning time for unpacking in seconds	No default, must be input
1	TE	"	"	Ending time for unpacking in seconds	No default, must be input
1	IC	"	"	Channel for which data is provided	IC parameter used in processing module (See Table 13)
1	NP	"	"	Number of data points per second; must agree with value in processing input	NP=16
2	ND	"	NAMELIST "PRMTRS" for program UNPACK	Number of data points read for which one datum is printed	ND=NP*9
2	TK	"	"	Time in seconds for which time in border is offset from times in data read; gives option of offset (not used for typical processing)	TK=0
2	PB	"	"	Beginning time for printed output in seconds	TB parameter used in processing module (See Table 13)
2	PE	"	"	Ending time for printed output in seconds	TE parameter used in processing module (See Table 13)
2	NOSCZG	"	"	0 - time for which a saturate calibrate, zero, or gap is encountered are printed 1 - only total # of occurrences of preceding conditions printed	NOSCZG=0
3	7/8/9	End of Record			
4	SCPI	n/a	NAMELIST "PRMTRS" for program BPLOT	Seconds per inch of horizontal scale on strip chart plot 10 sec/in is standard for detailed online plots; 10 inches of plotting surface is available to the Textronix so 30 sec/in suitable for displaying 300 sec of data	No default, must be input
4	VTPIR	"	"	Volts per inch for plotting PHI and r·v x B. (4.0 volts/ in. is a standard value which allows all plots to run successfully without exceeding plotting surface; 2.0 volts/in may be used for weak signals.)	No default, must be input
4	VTPID	"	"	Volts per inch for plotting PHI - r·v x B.	No default, must be input

Table 14. Punched Card Input for Plotting Module

4.2.2 Permanent Files

Permanent files RV•AB•REV and RV•ORMG are outputs of the PROCESSING MODULE and inputs to the PLOTTING MODULE. These files will be described only once, here in the discussion of input.

a) Name: RV•AB•REV

This file is accessed through BUFFERIN/OUT routines. It contains a nine word header record and 510 word packed data records. The header record is structured as follows:

Word Number	Contents	Format Type
4	Orbit number	F
1	Channel Number (not currently set)	I
8	Sample rate (not currently set)	F
6	Request start time-seconds	F
7	Request end time-seconds	F
9	First time on file-seconds	F
5	Orbit data	A
2	Year	I
3	Julian day	I

The packed data records contain 510 words. There is one word of packing information. The remaining words contain appropriately scaled integer values of PHI and PHI-$\bar{r} \cdot \bar{v} \times \bar{B}$. Each variable is allocated 15 bits; thus there are two time samples per 60-bit CDC word.

b) Name: RV•ORMG

This file contains the record for the processed orbit obtained from the B/L ephemeris tape.

4.2.3 Magnetic Tapes

The DETAILED PROCESSING System makes use of the same input tapes as the STANDARD ELECTRIC FIELD System. Refer to Section 3.2 and Table 7 for specifics.

4.3 Output

Printed output from program UNPACK consists of listing the header contents for permanent file RV·AB·REV. This file is described in section 4.2.2. The input values provided to program UNPACK are also listed.

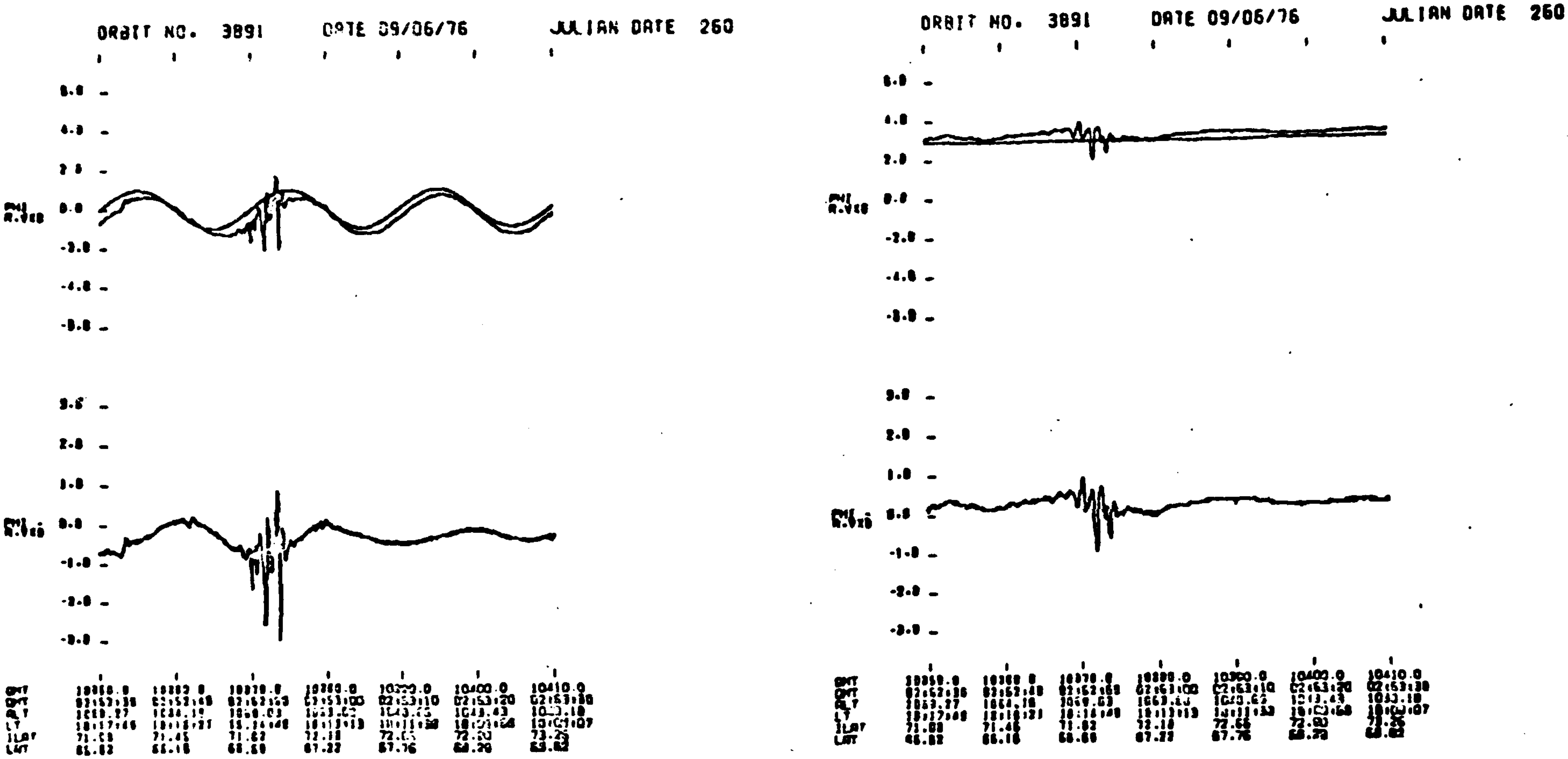
Time, PHI, PHI-$\bar{r} \cdot \bar{v} \times \bar{B}$, and $\bar{r} \cdot \bar{v} \times \bar{B}$ are then printed at the selected print frequency. Whether the datum is output and whether a saturate/calibrate or zero/gap condition prevails for the particular datum is indicated by the letters "OT, SC, ZG". Depending on choice of option, the total number, only, of the above conditions is printed; or a detailed list of the actual data points involved is provided. The lefthand margin of this listing gives packing infomation; buffer length for the header is given. Then buffer length, record number, word in the record, and the half of the word associated with the first datum in a block of nine is printed; each of these numbers uses I3 format.

To estimate the size of the output listing, note that 198 data points are printed per page. Only a single copy of the listing is printed.

The type of plot generated by this system is illustrated in Figure 11. Note that, for the selected channel, PHI, $\bar{r} \cdot \bar{v} \times \bar{B}$, and PHI-$\bar{r} \cdot \bar{v} \times \bar{B}$ are presented in the plot.

4.4 Analytical Procedures

The processes of packing/unpacking of data, plotting, and E-field evaluation are performed in a variety of software routines as follows.



a) Rotating Boom

b) Axial Boom

Figure 11. DETAILED PROCESSING System Plots for S3-2 Orbit 3891

4.4.1 Program ORBIT

The header of the satellite data tape is read and the proper time interval on the tape selected. Header information is written to TAPE3. Data from the required channel of the electric field experiment is unpacked and converted from telemetry units to volts. The predominant field measured is the induced field ($\bar{v} \times \bar{B}$), where $\bar{B}$ is the magnetic field of the Earth measured in the frame of reference rotating with the Earth and $\bar{v}$ is the velocity of the satellite with respect to the frame in which $\bar{B}$ is specified. Thus the voltage, V_a, due to ambient fields is given by:

$$V_a = PHI - \bar{r} \cdot (\bar{v} \times \bar{B})$$

where

PHI = Measured voltage
$\bar{r}$ lies along the dipole antenna axis,

and

$\bar{v}$ = Velocity of satellite referenced to the B measurement frame,

now

$$\bar{v} = \bar{v}_s - (\bar{W}_e \times \bar{Y}_s),$$

where

$\bar{W}_e$ = Earth's rotational angular velocity,
$\bar{Y}_s$ = Position vector of satellite measured from center of Earth

and

$\bar{v}_s$ = Velocity of satellite with respect to the vertical frame

Values of PHI, PHI-$\bar{r} \cdot \bar{v} \times \bar{B}$, and time are written to TAPE3. If a zero or gap is encountered, there is no output to TAPE3. If a saturate or calibrate is encountered, the values for PHI and PHI-$\bar{r} \cdot \bar{v} \times \bar{B}$ are set equal to zero.

4.4.2 Program KTPACK

Using the CDC system routine BUFFER OUT, the header record from TAPE3 is written to TAPE1. Voltages read from TAPE3 are scaled to 15 bit accuracy. Missing data is flagged. Data is then output, uniformly in time, to TAPE1 using subroutine PACKUP.

4.4.3 Program UNPACK

The packed data tape produced by program KTPACK is unpacked using subroutine PACKUP. Conditions for the data are determined. Optional output is provided.

4.4.4 Program BPLOT

A sample Tektronix plot produced by this program is shown in Figure 11. The top plot shows PHI and $\bar{r} \cdot \bar{v} \times \bar{B}$. For the online plotter, PHI is plotted in black and $\bar{r} \cdot \bar{v} \times \bar{B}$ is plotted in red. On a single color plot $\bar{r} \cdot \bar{v} \times \bar{B}$ can usually be identified as a smoother trace than PHI. The bottom plot show PHI - $\bar{r} \cdot \bar{v} \times \bar{B}$, i.e., the potential due to ambient electric field. A border with ephemeris information is plotted.

4.5 System Files

Tables 15 and 16 list, by program, the input and output files used within the overall DETAILED PROCESSING System. The tables are intended to convey the flow of information through the system as successive stages of processing are performed.

4.6 Operational Procedures

The DETAILED PROCESSING System is run as a two part job using two decks. The first part, Detailed Processing, processes the requested tapes and sets up a plot file. The plot file is then processed by the second part, Detailed Plotting, which creates an online (optionally, offline or Tektronix) plot. The deck set-up for each system follows.

Program File Name	CCL Procedure File Name	Description
Input		
	DT	data tape
	OM	OM tape
	OR	ORMAG tape
Output		
	DATA	copy of data tape
	OMOM	copy of OM tape
	ORMG	copy of ORMAG tape

(Note: ACCESSPC accesses one tape and copies the proper file to a scratch file. Thus ACCESSPC is used three separate times, once for each tape shown in the table.)

ACCESSPC

Program File Name	CCL Procedure File Name	Description
Input		
TAPE1	DATA	data tape file (generated in ACCESSPC as DATA)
TAPE5	ORBITIN	CCL namelist data file
TAPE2	ORMG	ORMAG tape file cataloged as RV·ORMG (generated in ACCESSPC as ORMG)
TAPE4	OMOM	OM tape file (generated in ACCESSPC as OMOM)
TAPE9	INPUT	CCL namelist read data file
Output		
TAPE6	OUTPUT	listed output
TAPE3	ORBT03	internally used file

(Note: Program ORBIT input file ORMG is copied to a scratch file AAAA and cataloged as pf file RV·RV·ORMG. AAAA is returned. Program KTPACK output file KTPK01 is copied to scratch file AAAA and cataloged as pf file RV·AB·REV.)

ORBIT

Program File Name	CCL Procedure File Name	Description
Input		
TAPE3	ORBT03	internally used file output from ORBIT
Output		
TAPE1	KTPK01	packed data cataloged as RV·AB·REV

KTPACK

Table 15. Input/Output Flow through DETAILED PROCESSING System

Program File Name	CCL Procedure File Name	Description
Input		
TAPE1	TAPE1	attached RV·AB·REV file (cataloged in DETAILED PROCESSING)
TAPE5	INPUT	Namelist (REQRNG)
Output		
TAPE8	TAPE8	header
TAPE6	OUTPUT	listed output

UNPACK

Program File Name	CCL Procedure File Name	Description
Input		
TAPE5	INPUT	Namelist (PRMTRS) (generated in UNPACK as TAPE8)
TAPE8	TAPE8	header (generated in UNPACK as TAPE8)
TAPE9	TAPE9	attached RV·ORMG file (cataloged in DETAILED PROCESSING)

BPLOT

Table 16. Input/Output Flow through DETAILED PLOTTING System

4.6.1 Phase 1: Detailed Processing

A typical run-deck for phase one is the following:

```
LOBOB,T1000,CM110000,NT1.  3102 GEDDES
VSN,DT=V3396,OR=CC0822,OM=CC3255.RV=2681B
ATTACH, PRDFL, PCPLTBPACKPC, ID=GEDDES, MR=1.
BEGIN,PRDRN,PRDFL,DTFL=5,ORFL=19,OMFL=21,RV=2861,AB=B.
7/8/9
$REQRNG TB=77220.,TE=77640., IC=6, NP=32$
7/8/9
6/7/8/9
```

As in the case of STANDARD ELECTRIC FIELD Processing, the DT, OM, and OR tape numbers have to be looked-up for each REV. But in DETAILED PROCESSING the OM and OR file numbers must also be looked-up and input to the BEGIN card. The file for the DT tape is always 5. (Note: A given REV might have more than one OMFL and DT tape assigned to it. If the DT tables show there is a time window next to a specific REV, the tables should be checked further to determine whether there is a second DT tape for that REV with a different time window next to the REV number. If not, there is only one DT tape for that REV; and thus the REV is not split. On the other hand, if there are two DT tapes for the requested REV, the REV is split. If the requested time window falls within the earlier time frame, then that DT tape is used and the REV is labelled A. If the requested time matches the later time frame, the corresponding DT tape is used and REV is labelled B. If the REV is not split the AB= parameter is a blank (AB= .). There may also be more than one OMFL for a given REV. If this is the case, there is no way to identify which is the correct one. Therefore if the first run fails, the second run, with a different OMFL, should succeed. There is one data card for DETAILED PROCESSING. It contains namelist data consisting of the begin and end time of the requested period, and IC and NP parameters which represent the channel number and data rate specified by the requester. The begin and end times must be input, for they differ from request to request. A successful Phase 1 ("Detailed Processing") run will create two permanent files which will be attached in Phase 2 ("Detailed Plotting").

4.6.2 Phase 2: Detailed Plotting

```
LOBOB,T200.  DETAILED PLOTTING   3103   GEDDES
ATTACH,PRDFL, PCKPLTBPLOTPC,ID=GEDDES, MR=1.
BEGIN,PRDRN,PRDFL,RV=1780,AB= ,CY=1.
7/8/9
$REQRNG TB=40500.,TE=41100.,NP=32$
$PRMTRS NOSCZG=1$
7/8/9
$PRMTRS SCPI=10.,VTPIR=4.0,VTPID=2.0$
7/8/9
6/7/8/9
```

As output from phase one, two permanent files are created which have the REV number with the letters ORMG and REV after each (i.e., 1780ORMG and 1780REV). The files contain data to be plotted when permanent file PCKPLTBPLOTPC is attached. File PCKPLTBPLOTPC is a CCL procedure deck which attaches these two files, 1780ORMG and 1780REV, and plots the data. The BEGIN card must include the requested REV number. There are three input cards that are required for three namelist reads. Details of card set-up, together with default options, can be found in Table 14. Typically, the first card would contain the begin (TB) and end (TE) times and the data rate (NP) used in phase one. If the default options for the second card are satisfactory, that card could consist simply of the namelist name, i.e., $PRMTRS$. The third data card gives scaling factors: SCPI (seconds per inch of horizontal scale); VTPIR (Volts per inch for plotting PHI and r·v x B. A value of 4.0 should fit all plots; and 2.0 can be used for especially weak signals); and VTPID (Volts per inch for plotting PHI - r·v x B).

4.7 Error Indications

Two types of errors will cause job failure. The first is the failure of data spans for the data tape, the OM file, and the B/L Ephemeris file to overlap. In this case the indication is no results in listings and plots. The tape and file number should be checked. The second error type is the occurrence of irrecoverable parity errors or record fragments on a magnetic tape. The tape should be cleaned and the job rerun. If the error recurs, the tape should be recreated.

4.8 Program Restrictions and Computer Requirements

At a data sample rate of 32 samples/sec., one second of data is found to require approximately one second of CPA time for processing in the Packing Module. The core memory requirement for this operation is 100K octal.

The Plotting Module uses the default value of core memory. Sense switch settings for this module are as follows:

none set for online plot
switch 1 for Tektronix plot
switch 2 for offline plot.

A single plot not exceeding 500 sec of data should run under the default CP time. It is recommended that a pen plot not exceed this length so as not to overtax the rewinding capabilities of the hardware when plotting multiple traces.

5. References

1) Burke, W.J., et al "A Case Study of S3-2 Observations in the Late Evening Auroral Oval", AFGL-TR-79-0011 (1979). AD A072996

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3) The Boeing Co., Document No. D233-10002-1.

4) D.E. Delorey, "Data Processing for S3 Satellites", Boston College, AFGL-TR-77-0103, 1977. AD A041912

5) "User's Manual for Output Module of the Small Satellite Attitude Determination Program", Boeing Co., Document No. D233-10036-2.

6) "Manual for Using Boeing's Output Module (OM) - B.C. Modification - Version 74274", Unpublished Note, Boston College, October 11, 1974.

7) McInerney, R.E., and Abelowitz, A., "Magnetic Field Package", AFCRL-TR-73-0356, 1973. AD 766208